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Aerial Spraying Technology in North American Forestry — Past, Present and Future?

The technology involved in the successful application of insecticides in forestry is tremendously complex and imperfectly understood. A host of factors affect the droplets that are produced during the time between their emission and approach to the general target area, their penetration into the canopy and deposit on the target area, and their interception by and effect on the specific target insect concerned.

Factors such as the physicochemical characteristics of the tank mix, droplet generating characteristics of the atomizing hardware used, and the volume rate of emission and characteristics of the aircraft employed, all have their individual and combined effects on the spray droplet spectrum that is emitted. Once emitted and on its way to the general target area, the spray cloud's behavior and ultimate fate is affected by the distance it must travel, the influence of the aircraft wake and wing vortices, and the effect of weather on the movement of the spray cloud and on individual droplets (i.e., evaporation). As the spray cloud moves into the target canopy, its penetration of and deposit on this canopy is affected by droplet size, air movement, windshear and turbulence, aircraft wake, and the density and configuration of the target foliage itself. Finally, interception of the insecticide by the target pest is influenced by the activity and behavior of the pest, phenology of the plant target species, and many other subtle interactions that occur at the pesticide/target interface. This sketchy and incomplete general description of events that take place applies to any aerial application of insecticides, but where forestry use is concerned, the situation is made even more complex by higher elevations at which spray aircraft must fly (relative to agriculture), difficulties in precise positioning of aircraft on flight lines, topographical variations, variability of the forest canopy, and the large and irregular areas that are commonly treated.

Although the technology involved with successful aerial application of insecticides in forestry is, indeed, complex, some real advances have been made. The first aerial applications of insecticides to control forest insect pests in Canada were made in the late 1920's using calcium arsenate dust with techniques borrowed from the U.S. experience in protection of cotton crops. Following these early attempts, no aerial applications were made in forestry in Canada until the mid-1940's, when DDT was used at very high dosage rates against the western hemlock looper in British Columbia and the spruce budworm in Ontario, Quebec, and New Brunswick. The application technology was inherited from the agricultural experience and applied to the forestry problem, largely in an ad hoc fashion, and with little knowledge of the parameters now known to influence the technology of aerial pesticide application.

In 1951, the Canadian Forestry Service (CFS) established the Chemical Control Section to begin looking into various aspects of application technology (among other things), and this section was subsequently strengthened to become the Chemical Control Research Institute in 1953.

Over the next two and one-half decades, this Institute, cooperatively with other CFS establishments and Provincial forest protection agencies, and working primarily with the spruce budworm in the East, contributed significantly to advances in improved technology for the aerial application of insecticides in forestry. Some of these advances included a shift to much lower volumes of application; improvements in spray atomization hardware; definition of the meteorological conditions then thought to be optimal for forest spraying operations; development of appropriate spray emission hardware; tank mixes and application of computerized guidance systems for large, multiengined spray aircraft; development of calibration techniques for spray systems; spray deposit assessment techniques for spray deposited at ground level and in the canopy; utilization of the concept of incremental deposit; and determination of the timing window relative to host tree phenology and target insect development during which sprays could be applied most efficaciously.

These and other advances in application technology, together with the availability of new and improved insecticides, have provided forest managers with techniques for reducing the damage caused by major defoliators, such as the spruce budworm, and for keeping forests alive during budworm outbreaks while, at the same time, minimizing environmental impacts. Parallel developments in application technology have occurred in the United States.

Beginning in the 1970's, a renewed emphasis was placed on research and development in application technology. This was brought about largely because of environmental concerns, but also with fewer new forestry-use insecticides coming on stream, we realized that if advances in forest protection were to be made, we would have to use the available products more effectively. During this period the USDA Forest Service (FS) was involved in the development of mathematical models that predict spray cloud behavior. Development of these models has, of necessity, been accompanied by the development of data for input into the models on a wide variety of subjects (e.g. accurate measurement of drop size distribution from various dispersal systems at various flight speeds, a wide range of aircraft characteristics, meteorological conditions, and to a certain extent, the biological interface). Two basic model systems are concerned — the FSCBG (Forest Service Cramer, Barry, Grim) model and the AGDISP code or model. The FSCBG model, in its various forms, has been in existence for over a decade, and is based on Gaussian plume behavior. The AGDISP

code or model, a much more recent development, is concerned with the behavior of discrete droplets and the effect of aircraft wake and other characteristics on this behavior. Either system can be used independently to predict spray behavior, but future developments will likely see the AGDISP code incorporated into the FSCBG model through a coupling code. The model has been used to predict spray cloud behavior in a number of FS spray operations, and predictions have been reasonably close to observed spray cloud behavior. Our American colleagues feel that the model is sufficiently far advanced to be used in planning and conducting forestry aerial spraying operations, including establishment of adequate buffer zones and prediction of near- and far-field drift. According to the FS, the major shortcomings of these models are inadequate meteorological input, including air flow within canopies, the influence of drainage flow, and development of a terrain winds model component.

In Canada, the New Brunswick Department of Natural Resources commissioned a task force in 1978 to investigate drift from aerial spraying operations against the spruce budworm. Forest Protection Limited funded several studies by scientists at the University of New Brunswick (UNB), the National Aeronautical Establishment of the National Research Council, and the N.B. Research and Productivity Council. This work led to a much better understanding of the drift phenomenon and the factors that contribute to it. Developing from these initiatives, the New Brunswick Spray Efficacy Research Group (NBSERG) was formed as a cooperative research group with Provincial support and dedicated to optimizing New Brunswick spray operations through a concerted approach to those processes affecting spray cloud emission, behavior, deposit, and biological effect. Cooperators in this venture, which is New Brunswick-oriented but will undoubtedly have broader application, include UNB, the Maritimes Forest Research Centre (MFRC), National Research Council, N.B. Research and Productivity Council, and the Forest Pest Management Institute (FPMI). NBSERG is also in communication with, and involved in cooperative work with the FS Methods Application Group and with researchers at the University of Georgia.

In the context of N.B. spray operations, NBSERG is attempting to cover virtually all aspects of the research needed to improve application technology, from atomizer design and formulation additives, through spray cloud behavior, to the complicated area of insect/deposit interaction. By definition, the work is involved primarily with applications by TBM aircraft, the mainstay of the current N.B. spraying operations. Some substantial advances have been made in mathematical modelling of spray cloud behavior and impaction on foliage, and on various aspects of the pesticide/biological interface. There is no question that the approach taken and the information generated will lead to improved application technology for budworm (and other) spraying operations.

Since the FPMI was formed in 1977, attempts have been made to develop a strong capability in application technology research and development. This has been a slow process because of the general unavailability of suitably qualified and experienced researchers. However, FPMI now has a formulation chemist, Alam Sundaram, who has already done much work investigating the physicochemical properties of various pesticide formulations, their individual components, and tank mixes made from them. A wind tunnel/spray chamber facility has been constructed, calibrated, and brought into full operation. It is used in initial determination of spray cloud characteristics of new formulations or modified tank mixes; for deposition characteristics of droplets of different sizes on a variety of collection surfaces, including foliage; and for a variety of other uses. Work is also being conducted on the effect of formulation components and spray additives on impaction, spreadability, adhesion, penetration, retention, and persistence of the active ingredient on foliar surfaces. Data generated from this research will provide required information basic to virtually all elements of application technology.

In 1983, Nicholas Payne, who is a spray cloud behaviorist, joined the Institute's application technology research team. Research within this project will include measurement of initial droplet size spectra for a range of atomisers and settings used in forestry applications and investigation and quantification of the effects of physical parameters on spray cloud dispersal and deposition. This core group, which will interact closely with other established groups at the Institute (e.g., insecticide toxicology, environmental impact, chemical accountability, field efficacy, biological control agents), will be rounded out with a professional in dispersal systems when a suitably qualified individual can be found.

Concerning future research needs, because of the complicated technology involved in the aerial application of pesticides, the development of complex mathematical models describing the behavior of spray droplets and spray clouds is paramount to any significant improvements in application technology. These models will have to be rigorously tested, verified, and improved under actual operational conditions. Because of the complexity of this area and the relatively small number of experts on both sides of the border, it would seem prudent to join forces in a concerted approach not only to model development, but also to the development of definitive data bases required for input into these models. In other words, neither the United States nor Canada can afford the luxury of duplication of research and effort in this important area. Specific needs in both model development and required data bases have been outlined in the problem analysis that preceded the formation of NBSERG and in identified

shortfalls associated with the U.S. models. Refinement and verification of these needs, including additions to them, can best be accomplished through meetings and workshops of all of the principal actors involved on both sides of the border. These people can develop a cooperative action plan to approach the overall problem in a logical, stepwise manner. Our American colleagues have indicated their willingness to work cooperatively toward mutual objectives in any or all aspects of forest protection, and we should strengthen active interchanges where application technology is concerned.

This note was written for the CANUSA *Newsletter* and the emphasis has been on application technology associated with the aerial application of insecticides used in forestry. But essentially the same problems exist with the aerial application of herbicides, and we would be remiss not to include them in any approach to cooperative research and development in the important area of aerial application technology.

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Use of Digital Terrain Models in Studies of Western Spruce Budworm Population Dynamics and Impact

The use of digital terrain models in the study of the dynamics and impact of western spruce budworm populations has been intensively investigated at the Pacific Forest Research Centre (PFRC). In our system, elevations recorded at regularly spaced grid coordinates are used to graphically reconstruct the underlying topography. An interactive computer graphics system (SURFACE), developed at PFRC, lets users view the surface from any angle, allowing preparation of stereo pairs of pictures.

A companion program (REG), which permits overlaying and shading of digitized regions, has also been developed. Each year, the Forest Insect and Disease Survey (FIDS) of PFRC conducts an aerial survey of pest conditions, and maps the areas defoliated by western spruce budworm, and other pests. The boundaries of these defoliated areas have been digitized for use by the REG program.

The REG program permits overlaying of successive years of digitized defoliation records to define the boundaries of areas of a specified defoliation history. As we have already established the relationship of growth reduction to defoliation history, this facility gives us an opportunity to make relatively accurate, outbreak-wide estimates of budworm impact.

The REG and SURFACE programs have been combined in the SURREG system, which lets us map the areas of a given defoliation history onto the underlying topographic surface, as with the Anderson River 1976 defoliation pattern (fig. 1). The program permits automatic retrieval of the total area of a given history in relation to aspect and elevation. In figure 1, and the other examples of the system, the vertical scale has been exaggerated to enhance the visual interpretation of the topography.

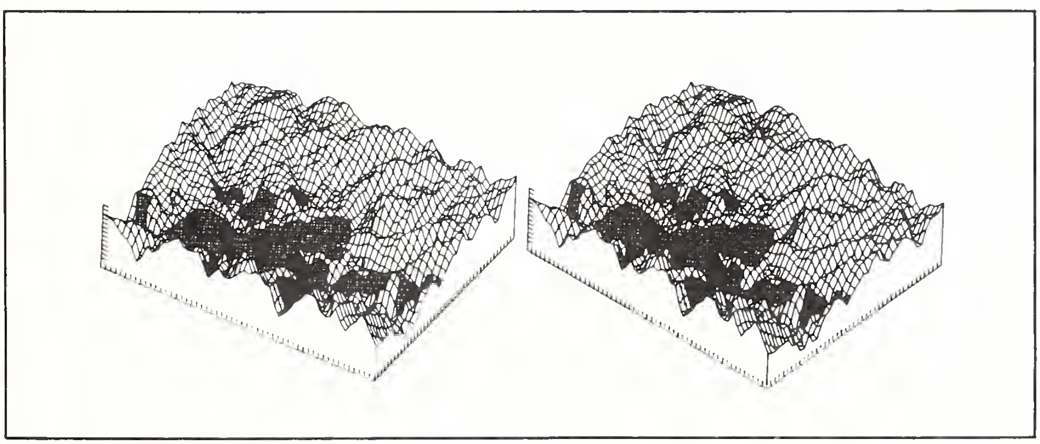

Figure 1. Digital terrain model of the Anderson River area of British Columbia showing the 1976 defoliation pattern. Grid lines here are 630 m (689 yd) apart.

We have shown that the relative phenology of Douglas-fir bud burst and western spruce budworm larval emergence in the spring is a key feature of the budworm population dynamics. Direct heating of buds and budworm hibernacula by the sun influences the timing of bud flush and larval emergence. The SURREG system can be used to define the areas which are in shadow with the sun in a particular position (fig. 2). The position of the sun at any time during the year can be calculated, as can the modification of solar radiation by slope and aspect. We plan to modify our system to define areas of equivalent rate of budworm development.

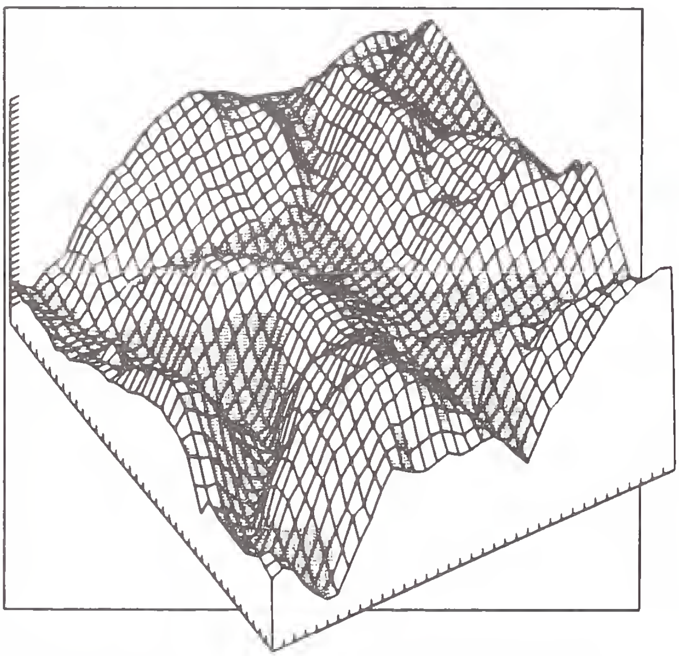

Figure 2 *Use of the SURREG system to determine the areas shaded when the sun is in a particular position. Here the grid lines are 250 m (273 yd) apart*

Digital terrain models have also been used in the development of wind models predicting wind flow patterns in mountainous terrain. These wind patterns may be used to aid interpretation of changes in observed patterns of defoliation from year to year, and may also be used to link areas in the dispersal phases of simulations of spruce budworm population dynamics. The raw elevation data extracted from topographic maps are too rough for direct application in a wind model. "Smoothing" of the surface must be done so that undesirable "noise" is not introduced into the wind model behavior. Unfortunately this smoothing wipes out the river valley features, which are usually the areas we are interested in. The final terrain data set is therefore obtained by putting back the river valleys — in effect gouging the valleys out of the smoothed terrain. The graphics system allows us to visualize the effects of our transformations on the terrain data.

Figure 3 is an example showing the sequence going from rough data (fig. 3a), to smoothed (fig. 3b), and finally smoothed with the river valleys superimposed (fig. 3c).

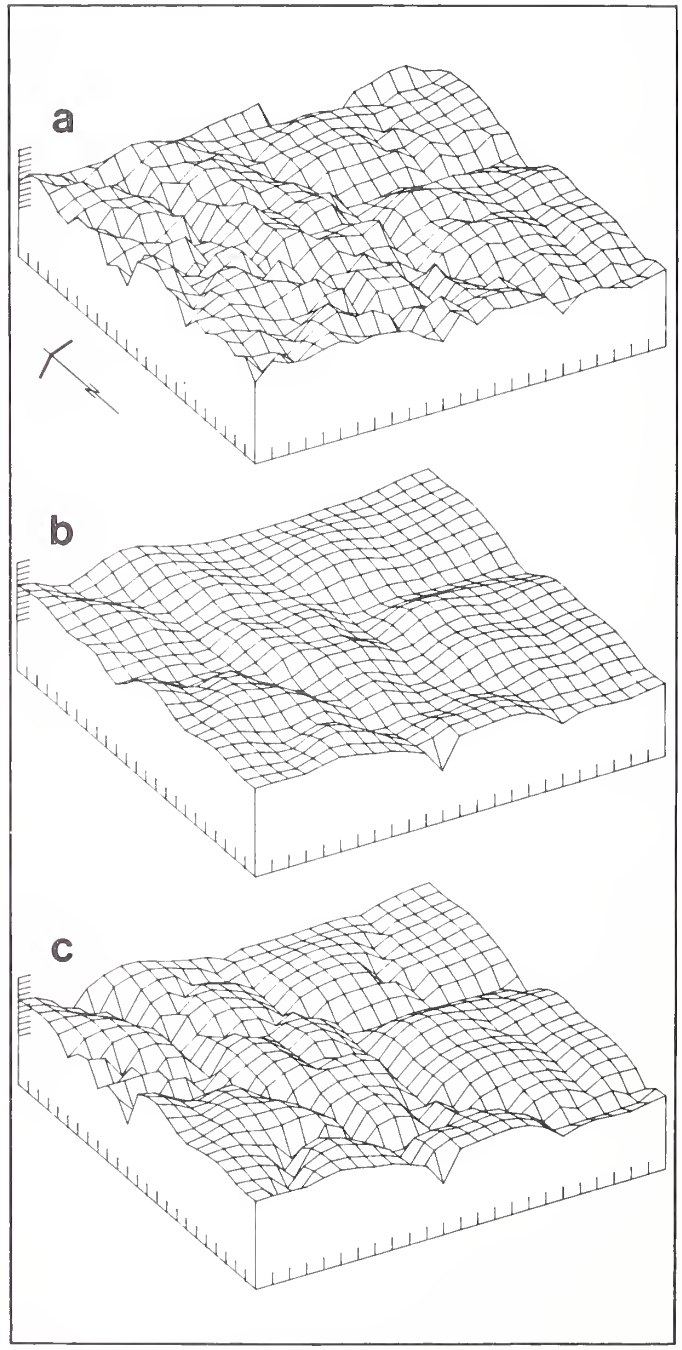

Figure 3. *Use of the system for evaluating (a) the original surface, (b) the smoothed surface and (c) the smoothed surface with rivers replaced, for use with wind models for mountainous terrain. In this example, which covers the Fraser-Thompson river region, the grid lines are 5 km (3 mi) apart*

The SURREG system gives an added dimension to simulation of western budworm population dynamics and impact. Simulation can be carried out within specific stands digitized from the British Columbia Ministry of Forests Inventory maps and these stands linked by dispersal routines.

The initial conditions within each stand and the dynamics during each iteration of the model can be displayed by differential shading of the stands; thus both the temporal and spatial patterns of an outbreak can readily be evaluated.

Computer graphics systems developed at the Pacific Forest Research Centre for use in digital terrain modelling provide a foundation for a wide range of studies of western spruce budworm population dynamics and impact and add a new dimension to simulation models of these two basic areas of defoliator research.

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Alternative Sources of Steinernematid Nematodes for Use as Biocontrol Agents Against Insect Pests in Newfoundland

During the summer of 1983 an investigation was begun at the Memorial University of Newfoundland to establish a cold-tolerant strain of steinernematid nematode for control of spruce budworm and other of forest insect pests in Canada. This was to be achieved either through laboratory adaptation of those nematodes currently available or by isolation of a naturally occurring species in Newfoundland and Labrador.

Candidate nematodes were isolated from soil samples, primarily forest soils, collected around the St. John's area, from across the Island, and from Labrador. The presence or absence of insect parasitic nematodes in the soil samples was determined by introducing late instar *Galleria mellonella* (the greater wax moth) into them. After 5 days exposure at 15°C (59°F), the samples were examined and all dead insects, whether introduced or occurring naturally were washed and transferred into white traps. The white traps were checked on a weekly basis for up to 8 weeks for the presence of nematodes emergent from the cadavers.

Using this method, 12 soil samples from the St. John's area, 49 from across the Island, and 4 from Labrador proved positive for nematodes.

The following procedure, used for the isolation and examination of one of the first insect parasitic nematodes discovered from the St. John's area, is also being followed for the nematodes found at the other sites. This work is at various stages of completion.

The nematode, collected from the white traps, was passaged through *G. mellonella* three more times, re-isolated from the soil, and passaged two more times. *G. mellonella* was then exposed to the infective stage of the nematode at 8, 12, 15, and 22°C (46, 54, 59, and 72°F), with the cadavers from each temperature dissected on a daily basis and developmental stages of the nematode removed. These were heat-killed, fixed, and processed so that permanent mounts in glycerin could be made. The time after exposure when mortality occurred and development rates of the nematode at the different temperatures were noted for comparison. The nematode, in this case, was found to be a steinernematid that carried a bacterium on which it fed inside the host. Bacterial smears on agar plates were made from the cadaver contents and three bacteria were found. Each bacterium was isolated on plates and an attempt was made to grow the nematode on each of them to define the nematode-associated bacterium. Once achieved, this would provide the basis for initiation of mass culture of the nematode *in vitro*.

From preliminary evaluation of the data obtained so far, it has been found that this nematode will cause mortality in a host over the whole temperature range tested, but notably at 8°C (46°F). Tentatively, the nematode has been identified as a strain of *Neoaplectana bibionis*, other strains of which have previously been found in Denmark and Czechoslovakia.

In summary, the soil survey yielded promising results with 19 percent of the soil samples containing insect parasitic nematodes. We are now at the stage where further investigations of the biology, life cycle, temperature range, and culture methods for these nematodes are essential so that a cold-tolerant nematode culture or cultures can be established for susceptibility testing against spruce budworm and other forest pests and eventual field use under Canadian conditions.

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Research Capsule: Latent Effects of Defoliation

In the course of CANUSA, reduced balsam fir growth following several years of heavy defoliation by budworm has been well documented by David MacLean and Harald Piene (Maritimes Forest Research Centre) and Dale Solomon (North Central Forest Experiment Station). Largely through their efforts, it is now possible to estimate, given varying levels of defoliation, the volume decrement caused by budworm feeding in still-living trees.

The reason growth is reduced is fairly obvious: storage reserves cannot long compensate for reduced photosynthate production. However, anatomical investigations of intact buds and needles from defoliated and nondefoliated balsam fir by Atlanta

University researchers Dillion Chen, Buhari Oyofo, and myself suggest that the course of events leading to growth loss may be more pervasive than previously supposed.

We found that fresh and dry weights of buds from defoliated trees are substantially less than buds from equivalent shoot positions on nondefoliated trees. Consequently, shoots that develop from such buds will be reduced in size and bear fewer needles than normal shoots.

Figures 4 and 5 are electronmicrographs of cross sections of cells from defoliated shoots and equivalent ones from nondefoliated trees, respectively. The ultrastructure and cytoplasmic organelle complement of shoots from defoliated trees differ from normal. At present it is impossible to assess the significance of these changes or whether they are transient (i.e., recovery follows cessation of feeding). But semiquantitive histochemical analyses of cytoplasmic enzymes in both types of shoots indicated a marked reduction in enzymes associated with the respiratory system in shoots from defoliated trees. Together these findings suggest that needle metabolism is disturbed in partially defoliated trees.

These anatomical and histochemical observations cannot be directly linked to photosynthate production, but it is fairly clear that intact needles from defoliated trees are not normal and that recovery of surviving defoliated trees following population collapse is by no means certain. It is also noteworthy that reduced foliar output of buds from defoliated trees would have the effect of accelerating back feeding and perhaps stimulating larval dispersal in trees subject to continuing attack.

A Closer Look at the Cells

The major differences between the defoliated and nondefoliated buds at the ultrastructural level are the occurrence of starch granules in the defoliated buds (fig. 4) and the absence of electron-dense granules (ED) as shown in figure 5a for the nondefoliated buds. The nondefoliated buds in figure 5b have a greater abundance of Golgi-derived vesicles than do the defoliated buds. There seem to be fewer mitochondria (m) in the defoliated bud cells, but this difference is not as readily obvious as in the case of starch granules and ED bodies. At this point, we can only speculate as to the absolute identity of the ED granules. Although similar structures based on ultrastructural appearance have been referred to as lipid bodies, we now prefer to call them protein granules. This at best is mere speculation.

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Research Capsule: Fenitrothion and Birds

Note: Following operational budworm spraying in 1978, concern was raised in Canada over the possibility that fenitrothion might be killing and/or retarding the growth rate of nestling birds. D. G. Busby, of the Canadian Wildlife Service in Fredericton, N.B., initiated a study to investigate that suspicion. This capsule summarizes his findings.

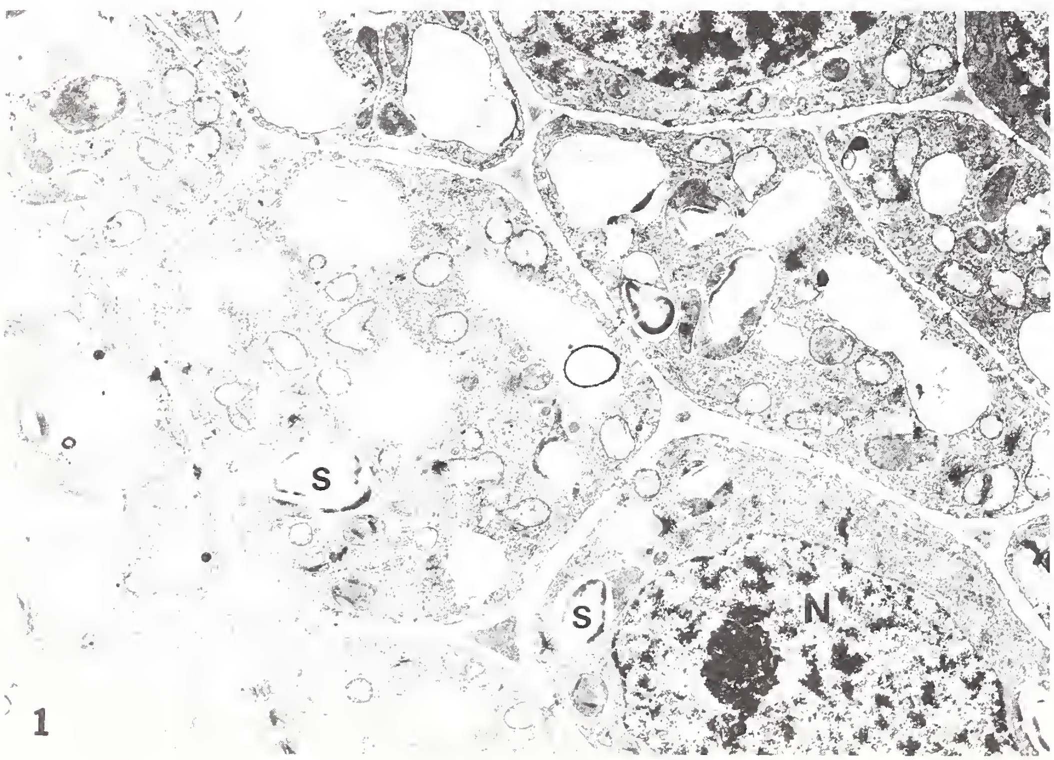

Figure 4. Section of balsam fir shoots from a heavily defoliated stand in Vermont. S = starch granules, N = nucleus.

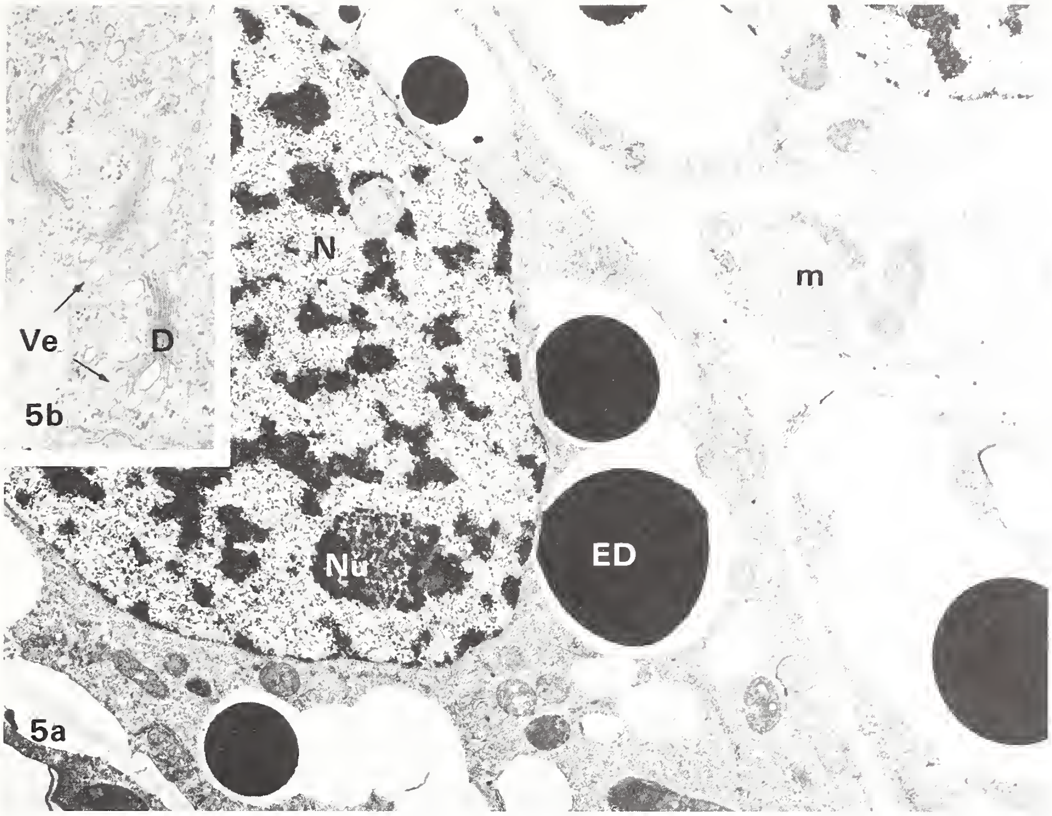

Figure 5. *Section of balsam fir shoots from an adjacent, nondefoliated stand. This photo and figure 4 contrast the ultrastructure condition of the shoot apices about 1 week prior to bud flush. 5a is a cross section shoot apex from a heavily defoliated tree, × 9,000. Inset 5b is a cross section of normal balsam fir shoot apex (× 10,000) collected at the same time as 5a. Nu = nucleolus, D = dictyosome, Ve = small vesicles, Ed = electron-dense material. Note the abundance of starch granules and large, essentially empty vacuoles in 5a compared to ultrastructure detail in the more highly magnified 5b, particularly dictyosomes and associated microvesicles and numerous electron-dense proteinaceous lipids in vacuoles.*

In studies in New Brunswick in 1978, Peters showed reduced nestling growth in white-throated sparrows (in terms of weight, by about 10 percent) in areas sprayed with fenitrothion compared to control (unsprayed) areas. But the exact cause of reduced growth was unclear because of other possible differences between sprayed and control areas. The study summarized here was designed to eliminate habitat differences between study areas and to establish toxicity tolerance levels for nestling white-throated sparrows.

Fenitrothion was introduced into nestlings via hair-cap moss capsules using a microsyringe (fig. 6). Each nest contained both control and experimental nestlings.

Figure 6. *Nestlings received fenitrothion via hair-cap moss capsules administered with a microsyringe.*

Figure 7 Wing length was measured daily

Nestlings were weighed and measured daily. Growth parameters included bill length and width, tarsus length, wing length, etc. (fig. 7).

Toxicity range-finding showed that a single dose at 0.039 microlitres/g caused 100-percent mortality in young hermit thrushes and Nashville warblers and 80-percent mortality in nestling white-throated sparrows.

Twenty nestlings received a single dose (0.007 to 0.039 microlitres/g) on day four. Eight nestlings received a double dose (0.007 microlitres/g) on days three and five. Eighteen birds were controls. Four nestlings received a single dose of 0.007 microlitres/g on day one.

Of the 20 receiving a single dose, 9 birds survived but showed reduced growth rates and lower fledgling weights. All of the birds that received a double dose survived, but all showed reduced growth rates and lower fledgling weights. Two definite "kinks" in the growth curve are evident. Of the nestlings receiving the fenitrothion on day one, three out of four died. Development of birds in the control group showed no change in the growth curve.

Several conclusions were reached as a result of this study. Fenitrothion killed some nestlings receiving doses as low as 0.007 microlitres/g, and it caused kinks in the growth curve of all nestlings at that rate of exposure. Younger nestlings are relatively more susceptible than older ones. The study supports the thesis that the reduction of growth rates in nestlings in the operational exposure situation reported in 1978 could have been caused by fenitrothion.

Silviculturists Meet in Spokane

Two hundred and fifty forest managers and silviculturists descended on Spokane in mid-February to attend a symposium on silvicultural management strategies for pests of the interior Douglas-fir and grand fir forest types. The meeting was jointly sponsored by CANUSA-West, the Society of American Foresters' (SAF) silviculture working group, and Cooperative Extension and the Department of Forestry and Range Management of Washington State University. Attendees earned category 1 credits in continuing forestry education from the SAF.

On day one (February 14), Applications Coordinator Russ Mitchell moderated the discussion of the interior Douglas-fir/grand fir forest types and their major pest problems. Here are some fast facts from this part of the meeting:

- Douglas-fir occupies one-fourth of the commercial land area in the northern interior West—the largest acreage of any species there.
- Ponderosa pine slightly leads Douglas-fir in annual volume cut.
- Selection cutting over the past century has increased the proportion of Douglas-fir and grand fir and led to uneven agedness and lowered value in residual stands.
- Physiological productivity of species in the inland West is governed by their ability to use available water efficiently.
- The most important bark-beetle enemies of the subject tree species are Douglas-fir bark beetle and fir engraver beetle. The main defoliators are western spruce budworm and Douglas-fir tussock moth. A new potential insect threat to interior grand fir is the balsam woolly adelgid, recently found nibbling on subalpine fir in Idaho.
- On National Forest land in northern Idaho and western Montana, about 15 percent of the commercial acreage is infested with root pathogens to the extent that at least one merchantable tree is killed annually on every acre (2.471 trees/ha).
- White pine blister rust has killed off so many white pines that, coupled with salvage cutting, it is responsible for converting many stands to grand fir.
- If you need to plan around deer and pocket gophers foraging in a reforestation situation, plant more than 400 seedlings/acre (988/ha) to compensate for their feeding.
- Research on coastal Douglas-fir has documented inherited resistance to damage by deer and snowshoe hares. But since "genetically resistant" trees are not yet available for propagation, a stopgap measure is to seed noncompetitive herbaceous plants that are tastier than Douglas-fir to deer and hares.

Day two (February 15) included six presentations on specific pests, featuring ecological relationships, impact, and hazard reduction. Gary Peterson (USDA Forest Service, LaGrande, Oreg.) moderated the discussions. Fast facts from these speakers:

• Annual volume losses caused by root diseases in the interior Douglas-fir/grand fir forest types are estimated at 120 million ft^3 (3,396,000 m^3). This volume converts to a band of wood made of blocks 1 ft^3 (0.0283 m^3) thick stretching clear around the equator!

• Grand fir, subalpine fir, and Douglas-fir are more severely damaged by root diseases than shade-intolerant species.

• The four diseases responsible for the most losses are armillaria root rot, laminated root rot, brown cubical root and butt rot, and annosus root rot.

• Soils associated with these root pathogens are low in nitrogen, phosphorus, and calcium, and high in potassium.

• Douglas-fir dwarf mistletoe can be found throughout the range of Douglas-fir in the Douglas-fir/grand fir forest types, but grand fir dwarf mistletoe does *not* occur in this area.

• Dwarf mistletoes of all varieties account for annual nationwide growth reduction of 400 million ft^3 (11,320,000 m^3). One-tenth of this damage occurs on Douglas-fir.

• Dwarf mistletoes can usually be controlled by routine silvicultural practices because these pests have a narrow host range, are obligate parasites, and spread fairly slowly.

• Shade-tolerant conifers, particularly in multistoried stands, are especially vulnerable to feeding by larvae of the western spruce budworm. Effective fire-control practices and uneven-aged forest management in the past 50 years have substantially increased the proportion of shade-tolerant species. Budworms: lunch is served!

• The best long-term solution to lessen the budworm's impact in managed stands appears to be intensive silvicultural treatment to promote healthy, vigorous coniferous stands.

• Weather in general, and late frosts specifically, are significant factors in western spruce budworm population dynamics.

• Douglas-fir tussock moth populations stay steady when survival from eggs to adults is low (around 1 percent). Natural enemies—insect parasites of eggs and pupae, and vertebrate and invertebrate predators of larvae—are credited with population control during nonoutbreak periods.

• In the Northwest, tussock moth outbreaks usually develop in stands on warm, dry sites with shallow soils (ridgetops and east- and south-facing slopes).

• To reduce losses caused by bark beetles, promote management practices that reduce tree wounding and soil compaction, increase species and age-class diversity, and increase stand vigor.

Part two of day two—a discussion of silvicultural management strategies—was chaired by Walt Knapp of the Pacific Northwest Forest and Range Experiment Station in Portland. CANUSA-West's ex-Program Manager and current consultant, Ron Stark, led off with a summary of integrated forest protection, an umbrella term enlarging on the principle of integrated pest management (IPM). Ray Hoff discussed the role of genetics in pest management. Ralph Johnson covered the implications of pest impacts on harvest scheduling by reviewing a study on the impacts of tussock moth on harvests on the Clearwater and Malheur National Forests. The day's last speaker, Mike Marsden, described the linkage of pest impact models with stand simulation models.

CANUSA cooperator Karel Stoszek chaired the panel on silvicultural systems for minimizing pest impacts. Speakers included two other CANUSANs: Wayne Maahs (member of the western technology transfer working group), and Dan Twardus (Region 6 CANUSA representative). Here are more fast facts, from day three:

• According to the Douglas-fir tussock moth hazard-prediction models, heavier defoliation can be expected on upper slope sites, in mature and overmature stands, and in stands with higher proportions of grand fir.

• Silvicultural management to lessen the likelihood of tussock moth and western spruce budworm damage should focus on enhancing nutrient cycling, the organic content of soils, and their mycorrhizal activity. Managers should also encourage species diversity (preferring Douglas-fir over the true firs) and favor seral, shade-tolerant species.

• Insect and disease control makes good financial sense. A root-rot-infected stand yielding 40 percent of normal can break even at about 6.5 percent return financially, but it produces a rotation yield of only 10,968 board feet/acre (153.5 m^3/ha) in 75 years. A healthy stand will return \$76/acre (\$188/ha) at 7 percent and produce 27,420 board feet/acre (384 m^3/ha), in the same period. That's 150 percent more wood!

• The continuing western spruce budworm problem in the West can be traced to economic selection harvesting that has removed nonhost species (ponderosa pine, western larch) and left the hosts behind to regenerate cutover sites.

• The primary silvicultural systems being used to minimize western spruce budworm impacts are shelterwood and clearcut where no viable understory exists. Overstory removal and stand cleaning are used where understory is viable. During regeneration and cleaning, nonsusceptible species are favored. The goal is a mixed stand through the rotation.

• Root disease may be the most serious long-term pest management problem of the Douglas-fir and grand fir forest types of the interior West. Estimated volume losses to root diseases just in northern Idaho and Montana exceed 80 million ft^3/year (2,264,000 m^3/year). Armillaria and laminated root rots are the most damaging pathogens.

The large size of the audience made genuine dialogue between the speakers and listeners a difficult proposition. Symposium organizers anticipated the problem, though, and solved it by asking the audience to write down their questions on three-by-five cards

during the talks. Then at the end of each subsection, all the speakers reassembled at the microphone to take turns reacting to the questions.

• This event, probably the largest single gathering sponsored by the western component, is part of their continuing effort to distribute the results of CANUSA research to a broad-based community of users throughout the West.

Janet Searcy — Information Coordinator
CANUSA Program
Washington, D.C.

Discussion Sessions Lined Up for the September Symposium

Chris Sanders and Ron Stark have finalized the agenda for both the synthesis papers and discussion sessions at CANUSA's international research symposium. The symposium is scheduled for Monday, September 17, 1984, through 4 PM on Thursday, the 20th. It will be held at the Bangor Civic Centre, with attendees staying nearby at the Bangor Holiday Inn. Chris and Ron have tried to mesh each discussion with the synthesis paper presented on the same day. At presstime, the following participants have been scheduled.

Monday, September 17. From 9:30 to 3:00, the audience will hear about the biology, ecology, and population dynamics of the spruce budworms. The moderator has not been selected yet, but the contributing speakers include George Harvey (Great Lakes Forest Research Centre) on taxonomy, Bob Blais (Laurentian Forest Research Centre) on *Choristoneura fumiferana*, Roy Shepherd (Pacific Forest Research Centre) on *C. occidentalis*, and Jan Volney (University of California at Berkeley) on the commonalities and differences among budworm species.

From 3:00 until the crowds drift away, Max McFadden (USDA Forest Service) will chair the first discussion session. The theme is, "How close are we to predicting the occurrence, severity, and duration of outbreaks, and to understanding the processes responsible?" Six invited participants will discuss the influence of various life forms and phenomena on budworm:

Bob Campbell (USDA Forest Service)—Predators
Mark Houseweart (University of Maine)—Parasites
D. Perry (Forest Pest Management Institute)—Diseases
Roy Beckwith (USDA Forest Service)—Budworm behavior
Bill Mattson (USDA Forest Service)—Host plant/budworm interactions
Allan Thomson (Pacific Forest Research Centre)—Environmental factors

And Chris Sanders (Great Lakes Forest Research Centre) will lead the discussion on (1) what we can learn from the historical records, and (2) what the theoretical interpretations are.

Tuesday, September 18. Ken Runyon, coauthor of the economics chapter in "Managing the Spruce Budworm in Eastern North America" and resident economist at the Maritimes Forest Research Centre, will chair the presentation of synthesis papers on the economic and social impacts of spruce budworms in North American forests. This session, from 8:30 to noon, will have four formal parts. D. A. MacLean (Maritimes Forest Research Centre) will speak on forest growth and yield. Tom Bible (Oregon State University) will cover other impacts. Brian Stocks (Great Lakes Forest Research Centre) will discuss fire, and Nick Crookston (CANUSA-West cooperator from the University of Idaho) will summarize new ways to forecast growth and yield.

Bill Waters (University of California at Berkeley) will take charge of the afternoon discussion session, from 1:00 to 6:00 (?), on population and impact assessment. The theme is, "Are current techniques adequate, and what new and modified techniques are available for quantifying populations and determining their impact?" Bill's speakers are Art Raske (Newfoundland Forest Research Centre) on determining insect numbers, Dale Solomon (USDA Forest Service) on quantifying impacts on forest growth and yield, and Bill White (USDA Forest Service) on quantifying the impacts of budworm on other forest resources besides timber.

Wednesday, September 19. From 8:30 to noon, Wyman Schmidt (USDA Forest Service) and Bill Varty (Maritimes Forest Research Centre) will lead the presentation of synthesis papers on tactics and strategies for prevention and suppression of damage by the spruce budworms. Bart Blum and Clint Carlson (both USDA Forest Service) will speak on stand manipulation in the East and West, respectively. Jack Armstrong (Canadian Forestry Service headquarters) will cover chemical insecticides, and J. C. Cunningham (Forest Pest Management Institute) will discuss biorationals.

In the afternoon, from 1:00 to 6:00, Wyman Schmidt will chair the discussion session on forest stands and budworm. His guests will tackle the question of how different stand types affect susceptibility and vulnerability, and what are the implications of stand-to-stand variation in forest management. Wyman shares the microphone with John Witter (University of Michigan) on the characteristics of susceptible and vulnerable stands, Dave Fellin (USDA Forest Service) on hazard rating, and Karel Stoszek (University of Idaho) on silvicultural remedies.

In the same time slot on Wednesday afternoon, a second discussion session will be held on techniques for foliage protection and population manipulation. Bill Varty is chairing this session. His speakers include Jackie Robertson (USDA Forest Service) on chemical controls, John Dimond (University of Maine) on biorationals, Charlie Wiesner (New Brunswick Research and Productivity Council) on application technology, and Peter Kingsbury (Forest Pest Management Institute) on environmental impact assessment.

Thursday, September 20. From 8:30 to noon, Ron Stark moderates the synthesis papers on integrating forest and pest management for (around?) budworm. Gary Simmons (Michigan State University) will speak on the eastern United States situation, Wilf Cuff (Maritimes Forest Research Centre) on the eastern Canadian situation, and Al Stage (USDA Forest Service) on the western situation on both sides of the border.

To end the symposium, from 1:00 to 4:00 PM on Thursday, a final discussion panel will tackle the big question: How successful has CANUSA been in meeting the needs of forest management? And what remains to be done? Bob Blomquist (USDA Forest Service) will chair the discussion. Jean-Claude Mercier, Associate Deputy Minister of the Quebec Department of Lands and Forests; and Wayne Maahs, Champion Timberlands in Montana, are presently on the schedule. Other participants will be announced. (We anticipate no shortage of non-CANUSAns willing to take a whack at the program, and we are hopeful that the discussion will help the decisionmakers within the USDA Forest Service and Canadian Forestry Service determine the future direction of budworm research once CANUSA shuts down.)

To get more information about the symposium, write to

CANUSA Symposium
Conferences and Institutes Division
University of Maine at Orono
126 College Avenue
Orono, ME 04469

The organizers are planning local tours of Bangor, coastal Maine, and the discount factory outlets in the region if interest is sufficient. Also on the docket: a Maine clambake dinner. If you have already written to indicate your interest in the symposium, you will automatically receive another mailing in June. If not, please contact the above address right away to get on the symposium mailing list.

CANUSA Tours: Lake States and Maritimes

As part of the program's technology transfer year, two outstanding field tours are planned for mid-1984. If July is a good travel time for you, plan to join us for the Lake States tour from the 9th through the 13th. The second tour—through Maine, New Brunswick, and Quebec—is timed for September 10-16, the week preceding CANUSA's international research symposium in Bangor. Both tours are free of charge except for your lodging and food. Registration details can be found at the end of this article. Here are the itineraries.

Lake States Tour

Monday, July 9—Arrive in Rhinelander, Wisconsin.

6-7 PM—Registration and icebreaker at the Holiday Inn, where tour guests stay overnight.

Tuesday, July 10—Transportation departs from the Holiday Inn.

Program video tapes on spruce budworm in the Lake States and silviculture of spruce and fir in the Lake States will be shown. Other stops include (1) Nicolet National Forest Headquarters, for a demonstration of the Geographic Information System with application to balsam fir and spruce budworm management; and (2) Monico, Wisc., Consolidated Paper Company and the Wisconsin Department of Natural Resources, for their approach to balsam fir and spruce budworm management. Regeneration of a site after spruce budworm damage will be featured. The tour returns to the Holiday Inn in Rhinelander for overnight accommodations.

Wednesday, July 11—Depart Rhinelander.

Stops include (1) the Eagle River District, to examine the economics of presalvage, salvage, and no-action alternatives for managing budworm; (2) Ottawa National Forest, Iron River Ranger District, for hazard rating of stands and silvicultural techniques. Overnight stop will be in Iron Mountain, Michigan.

Thursday, July 12—Depart Iron Mountain.

Stops include (1) Rapid River Ranger District, for a discussion of cutting strategies for spruce budworm-killed timber; (2) Escanaba, Michigan, for a tour of Meade Paper Company's mill and a description of their approach to balsam fir management. Overnight stop will be at the Golden Host Motel in Escanaba.

Friday, July 13—Depart Escanaba.

Stop at Champion International for a discussion of their management approach to budworm-infested lands. The tour bus will leave for Rhinelander between noon and 1 PM.

Maine/Maritimes Tour

The tour of spruce-budworm-damaged lands in Maine and the Provinces of New Brunswick and Quebec will give you a chance to see extensive fir and spruce mortality, the effects of spraying strategies, examples of management techniques to reduce budworm impact, salvage operations, and normal harvesting operations. Representatives from the various private, Provincial, and Federal organizations will be on hand to explain operations at each stop.

Timing for the tour has been coordinated with the start of the CANUSA international research symposium in Bangor on September 17. However, joining the tour does not commit you to staying for the symposium.

Monday, September 10—Arrive in Bangor, Maine.

At 1 PM, transportation departs from the Holiday Inn to the Penobscot Experimental Forest for a tour of their research area. Overnight accommodations are at the Bangor Holiday Inn.

Tuesday, September 11—Transportation departs from the Holiday Inn.

Stops include (1) St. Regis Paper Company lands, to see clearcut salvage areas with prescribed burning and conversion to black spruce, as well as precommercial thinning and partial cuts in various stands; (2) Brockway Airstrip, New Brunswick, where Forest Protection Ltd. will explain the 1984 spray program; and (3) Georgia-Pacific lands, to see large-area salvage cuts and stand conversion to jack pine. The tour will stay overnight in Fredericton, New Brunswick.

Wednesday, September 12—Transportation departs Fredericton.

Stops include (1) lands owned by J. D. Irving Ltd., to see stand conversion to black spruce on 150,000 acres (60,704 ha); and (2) the New Brunswick Department of Natural Resources and Fraser Company will show some of their silvicultural treatments on various stands. The tour will stay overnight in Rivière du Loup, Quebec.

Thursday, September13—Transportation departs Rivière du Loup.

Stops include areas treated by chemical and biological pesticides and areas in true boreal forest where some salvage operations are in place. Tentatively, the tour will be shown spray calibration for DC-4G aircraft. Finally, Wladamir Smirnoff will take the tour through his laboratory and discuss his work on *Bacillus thuringiensis*. The overnight stop will be in Chicoutimi, Quebec.

Friday, September 14—Transportation departs Chicoutimi.

Yvan Hardy, of Laval University, will show tour guests the Laval University Forest, and we will also see areas in Laurentides Park where salvage cuts and stand conversion work are being conducted. The tour will spend Friday night in Quebec City.

Saturday, September 15—Transportation leaves Quebec City.

Stops include (1) Scott Paper Company lands, to see precommercial thinning and operational biomass harvest with subsequent site preparation and planting to softwood. For a special treat, the overnight stop is scheduled for the Squaw Mountain Resort in Greenville, Maine. The package includes dinner buffet, lodging, and breakfast buffet on Sunday, the 16th. Per-person cost will be $58 for a single room, $38 for a double, $35 for a triple, and $34 for a four-person room. After breakfast on Sunday, the tour bus will return to the Holiday Inn in Bangor—just in time for attendees to register for the research symposium.

Registering for the Lake States Tour

Jim Hanson, USDA Forest Service, 1992 Folwell Avenue, St. Paul, MN 55108, is taking care of registration details for the Lake States tour in July. Write to Jim and let him know what kind of room reservation you want him to make for you (single, double, none on a particular night, etc.). Be sure to include a phone number where you can be reached, as well as your name, address, and organizational affiliation. Again, there is no charge for bus transportation or tour events. Your only out-of-pocket expenses will be for food and lodging. There is no prearranged deadline for registering, but you should probably notify Jim *before June 1* if you plan to attend.

Registering for the Maine-Maritimes Tour

Tom Skratt, Northeastern Forest Experiment Station, USDA Building, University of Maine, Orono, ME 04469, is handling the hotel and restaurant reservations for the September tour. As above, write to Tom to let him know your preferences on room reservations, phone number, address, and organizational affiliation. Deadline for registering for the September tour is *June 1*.

What's New with the Egg-Mass Counter?

Note: On March 7, 1984, Bill Ciesla (group leader of Forest Pest Management [FPM] Methods Application Group at Fort Collins, Colo.) filed a report to Jim Stewart (director of FPM and a member of CANUSA's Joint Planning Unit) on the status of the automated egg-mass counter being developed by the Program. This equipment, brainchild of Dan Jennings at Orono, is now in the final stages of refinement at the Forest Service's Missoula (Mont.) Equipment Development Center. This article is adapted from Bill's narrative report.

On February 23, 1984, representatives of CANUSA, the Missoula Equipment Development Center (MEDC), Forest Pest Management, the Northeastern Forest Experiment Station, and the Canadian Forestry Service met in Missoula to discuss the present status of the spruce budworm egg-mass counter.

Dan Jennings opened the meeting with a review of the development of the device. Its modus operandi is based on the fact that spruce budworm egg masses fluoresce when exposed to ultraviolet (UV) radiation. The foliage is exposed to UV light and a sensor, calibrated to detect levels of fluorescence in the violet and green regions of the electromagnetic spectrum, detects and records objects that fluoresce.

The first prototype was constructed by an optical physicist and an electrical engineer at the University of Maine during 1976–77. Testing of that model showed that branch examination time was reduced from 29 minutes/branch to 8 minutes/branch, and the correlation coefficient R2 between hand counts and machine counts was 0.97.

MEDC took over development of the unit in 1980 under CANUSA sponsorship and built a second prototype. The purpose of this effort was to develop a unit that could be adapted to both western and eastern spruce budworms and a variety of host foliage. The model was completed during 1983 and was shipped to Vermont for demonstration at a CANUSA technology transfer event. The trip was hard on the unit; a number of components had to be replaced, and it was nonfunctional for 6 to 8 weeks.

The second prototype was demonstrated during the Missoula meeting and is presently functional. Discussion of future development and testing centered on the following constraints:

1. Due to the fragile nature of certain components of prototype 2, the machine should remain in Missoula for further testing.
2. Fresh egg masses, the type that are normally counted during spruce budworm egg-mass surveys, will not be available from field samples until late August 1984.

Before field testing scheduled for fall 1984, a number of tasks relating to bench testing and software documentation are necessary, as well as development of a user manual. In addition, some basic data on machine performance are required. For example, we need to know how much error occurs due to the orientation of the egg mass on foliage relative to the scanner. Also, how much error do other fluorescing objects (e.g., lichens and pitch globules) introduce into the counts? As spruce budworm infestation begins to stress host trees, there is an increase in lichen growth on the branches. These sources of counting error must be examined and their influence quantified so the egg-mass counter can be adjusted to take them into consideration.

Bill Ciesla agreed to lead a task force to design a test of the machine's performance during September and October of this year. The task force will include FPM'ers Dennis Souto (Northeastern Area), Larry Stipe (Region 1), and Mike Marsden or Will Hoskins (Methods Application Group), Dan Jennings, Ed Kettela (Canadian Forestry Service), Jim Colbert (CANUSA-West), and Gary Simmons (Michigan State University). This group is scheduled to meet at St. Paul in April to draft a test plan.

The egg-mass counter's future in Fiscal Year 1985 and beyond involves these three steps at least:

1. Analyze and report results of the 1984 testing.
2. Revise manuals for use and machine maintenance.
3. If testing results are successful, seek alternative ways to produce operational models that are more rugged than prototype 2. This might include continued development at MEDC or contracting with a firm in the private sector.

One concern not resolved is who will provide leadership and funding to further the development of the egg-mass counter after CANUSA terminates in September 1984. Estimated costs for developing these units is $20,000 (50 percent labor, 50 percent parts). We anticipate needing no more than 20 spruce budworm egg-mass counters in both the United States and Canada. This need may be reduced in some areas, especially Maine, because second-instar larva surveys are replacing egg-mass surveys for defoliation predictions and selecting areas for treatment.

Out and About

Early March saw three new eastern handbooks in print. Paul Adamus's "Techniques for Monitoring the Environmental Impact of Insecticides on Aquatic Ecosystems" (Agriculture Handbook 613) had been held back from release by Forest Service printing specialists, who determined that a portion of the press run had been spoiled in the binding process. We insisted that the damaged boooks be reprinted at the contractor's expense, and our printing specialists successfully negotiated that for us. This book is being sold by the U.S. Government Printing Office (GPO). So far, it is the only CANUSA text that we know which will be sold through the GPO.

Dan Jennings's "Techniques for Measuring Early-Larval Dispersal of Spruce and Jack Pine Budworms" (AH 614) was also released in early March. This book describes both methods and equipment for measuring larval dispersal.

Finally, Bruce Montgomery's "Insecticides for Control of the Spruce Budworm" (AH 615) was released for distribution at the same time. This handbook covers costs for insecticide spraying and all the chemical and microbial controls currently registered for budworm. Especially useful to operators is table 5, which describes the insecticides by their common and brand names, formulation, dilution, and application methodology. A remarks column mentions the life stage to be treated, locations where the material can be used if that is restricted, and instructions on application technique. The text ends with a list of State pesticide specialists and poison control centers (hospitals) in the entire eastern U.S. budworm region where you can get specialized help in handling pesticide exposure.

If you need copies of these handbooks and have not already received them, contact the Northeastern Forest Experiment Station's publication distribution office at (215) 461-3106 or FTS 489-3106, or write directly to them at 370 Reed Road, Broomall, PA 19008. This location will continue to distribute the publications of CANUSA-East after the Program ends in September of 1984, as long as supplies last. And the National Technical Information Service (NTIS) will have all our publications in perpetuity, available for a charge in hard copy or microfiche. In the last issue of this *Newsletter*, projected for November 1984, we will supply NTIS order numbers and prices for all Program books in print at that time.

Erratum

In the January 1984 issue, in the article B.T. and the Spruce Budworm - 1983 by J. R. Carrow, the figures given for the cost application of B.T. beginning on line 12 under the subheading "Cost" are wrong. This section through to line 16 should read as follows:

"The average cost per BIU has declined from 68 cents in 1980 to 32 cents in 1983, resulting in reduced insecticide cost per hectare — $13.18/ha ($5.27/acre) in 1980 to $6.96/ha ($2.82/acre) in 1983 (Canadian dollars)."

We apologize for this error.

Personnel

Jimmie Joe Colbert, Program Manager at CANUSA-West in Portland, received a Certificate of Merit and cash award for exemplary performance of administrative responsibilities in the CANUSA Program. He was cited specifically for leading the team working on developing models to link budworm populations with defoliation and forest growth and yield.

The USDA Forest Service has managed to snare the full-time, permanent services of CANUSA-West insect modeller Kathy Sheehan, who has been working for the Program on a loan through the University of Idaho. After April 16, Kathy will be at Morgantown, West Virginia, working for the Northeastern Forest Experiment Station. She will be attached to Dave Donnelly's new project on silvicultural management of forests susceptible to the gypsy moth. In these times of tight budgets and personnel ceilings, it is especially gratifying to be able to bring someone with Kathy's qualifications into the Forest Service fold.

Items from the Press

No '84 budworm project. — The western spruce budworm infestation in eastern Oregon will be allowed to continue until it collapses in the next few years due to natural factors, or until a subsequent analysis determines that direct control measures are needed.

On Feb. 7, Region 6 of the Forest Service and the Oregon State Department of Forestry jointly announced a decision to take the "no action" alternative on western spruce budworm populations in eastern Oregon.

The decision is based primarily on new economic information that indicates a significantly reduced rate of increase in stumpage prices in future years when compared to prices used in 1982 and 1983.

The current infestation in eastern Oregon began in 1980. At the end of last summer, the infestation covered 2.4 million acres of forested lands on National Forests and State and private lands.

Almost 180,000 acres were treated in 1982 with the insecticide Sevin, and slightly over half a million acres were treated in 1983. From all indications, population levels within most of the areas treated have been brought back to levels that cause minimal growth loss, top kill, or mortality.

An infestation on the Mt. Hood National Forest is not included in the "no action" decision. A separate Environmental Assessment is being prepared on this situation.

(The Green Sheet — March 2, 1984)
USDA Forest Service, Region 6
Portland, Oregon

Spraying is essential. — Properly registered and properly applied herbicides and insecticides are "essential tools to agriculture and to forestry," Don Lockhart, Executive Director of the New Brunswick Forest Products Association said recently.

"A small, very small, but vociferous minority is doing its best to stop the use of vital agriculture and forestry chemicals, not on the basis of scientifically sound health and safety concerns, but to forward the lifestyle, world-view and political goals of anti-pesticide activists," Mr. Lockhart said in a brief to the New Brunswick Pesticides Advisory Board.

Pesticides are necessary to ensuring the quality and price of New Brunswick pulp, paper, and lumber remains competitive. "The price will not be right if we have to forsake herbicide use at the cost of about $65 per hectare and resort to hand clearing at about $300 per hectare," he said.

(Daily Gleaner — December 7, 1983)
Fredericton, New Brunswick

Biological insecticides in Quebec. — The Ministère de l'Energie et des Ressources has already announced its intention to make greater use of biological insecticides in its control program next year.

A spokesman for the office of the Minister, Yves Duhaime, recently said that the total area treated with these insecticides could be as large as 275,000 hectares, compared with 45,000 hectares last year.

Futura, a new version of the biological insecticide *Bacillus thuringienis* (B.t.) developed by the LFRC, cannot be used next year, however, unless it is approved very soon by the federal government.

(Le Devoir — December 10, 1983)
Montreal, Quebec
(Translated from French)

Recent Publications

The Forest Service has announced publication of *Silvicultural Systems of the Major Forest Types of the United States*. This lengthy black-and-white book is available for $11.00 from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20502. Ask for Agriculture Handbook 445, GPO order number 001-000-04322-b.

The Forest Pest Management Institute, P.O. Box 490, Sault Ste. Marie, Ont. P6A 5M7 can supply Information Report FPM-X-52 by P. D. Kingsbury entitled "Permethrin in New Brunswick Salmon Nursery Streams."

And the Pacific Forest Research Centre, 506 West Burnside Road, Victoria, B.C. V8Z 1M5 can supply reprints of

A. J. Thomson, R. F. Shepherd, J. W. E. Harris, and R. H. Silversides. "Relating Weather to Outbreaks of Western Spruce Budworm, *Choristoneura occidentalis* (Lepidoptera: Tortricidae), in British Columbia." Can. Entomol. 116:375-381.

In the Hopper

Two new publications have been added to our expected outputs. From the western component comes Steven Shattuck's "Illustrated Key to Ants Associated with Western Spruce Budworm." And from the easterners, Gary Fowler and Gary Simmons are supplying "Sampling Procedures for Spruce Budworm Egg-Mass Surveys." Both are expected to be published as USDA Agriculture Handbooks, and both will be coming to Washington for review and printing during April.

The two video tapes commissioned by the Joint Planning Unit and Joint Policy and Program Council are in final stages of preparation at the University of Michigan. Version one of the western tape was previewed for a small group of CANUSANs at the Spokane silviculture meeting described earlier in this issue. The second version of the eastern tape was received in Washington in mid-March. Both video tapes will be in final form very shortly, probably before you read this, and will be duplicated for use in the Program's summer 1984 technology transfer events. They will both be shown at our September international research symposium in Bangor.

"Managing the Spruce Budworm in Eastern North America" is in reproduction proof and should be laid out for printing by the time you read this. Printing should take place in June. The western management manuals had not arrived in Washington at presstime (mid-March), but two of the three will definitely be showing up by early April. The Pacific Northwest Forest and Range Experiment Station has signed off on the first and third volumes, and book two should have reached that stage before you receive this issue.

To get more information or to have your name added to the mailing list for the *Newsletter*, contact

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